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Cawangan Kedah  
Kampus Sungai Petani

Faculty of Administrative  
Science and Policy Studies

# i-SPIKE 2021

*Leading An Artificial Innovation In Knowledge, Education And Design*

## **i-SPIKE 2021 INTERNATIONAL EXHIBITION & SYMPOSIUM E-PROCEEDINGS**

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## ENCAPSULATION OF WINGED TERMITES IN CELLULOSE NANOFIBRE FOR THE FABRICATION OF CELLULOSE BIOPLASTIC

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### ABSTRACT

Currently, bioplastic has become a trend due to the undegraded petroleum-based plastic, hence leading to environmental pollution. Meanwhile, the winged termite swarmers come out when the environment is wet or damp, so they are often found after rain. Meanwhile, cellulose is the most abundant biopolymer on Earth. It is highly valuable, renewable, biodegradable, bio-compatible, and most importantly, not fully utilised. Hence, the aims of this study were to integrate winged termites and cellulose in the production of bioplastic and study the thermal and chemical properties of the bioplastic produced which will become an alternative to save the environment. Cellulose was dissolved in pre-cooled LiOH/urea solvent at -13°C to form a cellulose solution. Termite wings were then grinded using pestle and mortar. The termite wings powder was added and mixed with cellulose solution until it was fully dissolved. The termite wings powder-infused cellulose solution was cast on a glass plate and flattened out and consequently was coagulated in acid bath to form a cellulose membrane. The sample was then frozen and air-dried. From the FTIR analysis, the functional group of termites and cellulose were changed after the regeneration of cellulose and mixing with termites has been carried out. This portrayed that the reaction has taken place. The thermal properties of the bioplastic were investigated using DSC and revealed that winged termites have enhanced the thermal properties of the plastic. Consequently, this bioplastic also serves as green plastic which helps to reduce pollution by making bioplastics using the waste from natural source

**Keywords:** Biodegradable plastics; FTIR; green solvent; INAQ winged termites

## INTRODUCTION

Plastic or plastic bags that are commonly used in our daily life are mostly made of polyethylene. Polyethylene is an inert material that is very difficult to degrade thus making plastic bags harmful to the environment. Plastic bags can cause pollution which is bad for human's health, can harm marine creatures and wildlife, poisonous and many more. That is why it is a problem to the environment since it can cause further damage (Ghatge et al. 2020).

Cellulose is a long-chain polymer of glucose molecules joined together. It can be dissolved by using certain solvents including concentrated phosphoric acid, N-methylmorpholine-N-oxide, cuprammonium hydroxide and more. Cellulose can be used to produce regenerated cellulose hydrogel, paperboard, cellophane, films, bioplastic, and others. It also functions as a membrane and is an ideal candidate for medical modifications and for tissue engineering uses (Kaco et al. 2017).

Winged termite swarmers, scientifically known as Isoptera sp., are termites with wings. They leave their nest to reproduce and mate so new colonies are built. Usually, swarmers leave their nest during spring to fall, or when the weather is humid. The colour of the termites can be gray or pale brown depending on the species. Their wings are lightweight and thin, enabling these swarmers to fly easily. The winged termite swarmers are attracted to light which can damage their wings, thus that is why their wings have good thermal properties (Etuk et al. 2017; Miller et al. 2010). They are constantly at risk of drying out and dying from dehydration, so they mostly stay in the soil to find moisture. Their bodies are also high in protein, calcium and iron and are edible (Adepoju et al. 2014).

Therefore, in this study, cellulose was integrated with winged termite to produce bioplastic as a potential plastic with better thermal properties. The physical and chemical properties of cellulose and cellulose/termites were analysed. The surface morphology and the chemical changes observed were investigated.

## MATERIALS AND METHOD

### Materials

Oil palm EFB fibres were purchased from Szetech Engineering Sdn Bhd (Selangor, Malaysia) at desired sizes of 106 to 500  $\mu\text{m}$ . The isolation of cellulose was done using sodium chlorite and acetic acid (Sigma Aldrich). The dissolution of cellulose was done using lithium hydroxide, LiOH and urea (Sigma Aldrich). The coagulation bath was prepared containing 5% sulphuric acid, H<sub>2</sub>SO<sub>4</sub> (Sigma Aldrich).

### Preparation of EFB cellulose

Bleaching and alkaline process of kenaf was carried out. In bleaching process, buffer solution was prepared containing NaOH, acetic acid, sodium chlorite and distilled water reacted with kenaf at 80 oC. Consequently, the bleached kenaf was alkaline treated in 2% NaOH at 80 oC as well. After every single stage was performed, the sample was washed until neutral prior to entering the next stage. Then, the sample was dried at 105 oC for 24 h.

## Preparation of winged termite's powder

Winged termites were obtained from the surrounding of Kolej GENIUS Insan after the rain stops. The termite's wings were separated from its body and were grinded using pestle and mortar to obtain the powdered form of termite's wing as shown in Figure 1(a).

## Alkaline dissolution process

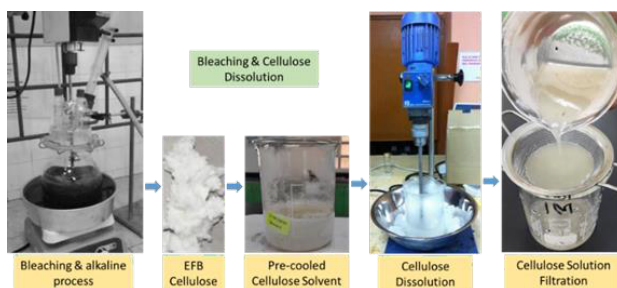
A green aqueous solvent of LiOH/urea with the 4.6 % LiOH, 15 % urea and 80.4 % distilled water was prepared and pre-cooled at  $-13$  oC in a refrigerator. Consequently, the extracted EFB cellulose was added into the frozen solid was thawed and stirred extensively at room temperature to obtain a transparent cellulose solution. The transparent solution underwent centrifugation at 10,000 rpm for 5 mins to remove gas bubbles as presented in Figure 1(b).

## Cellulose/termites encapsulation for bioplastic fabrication

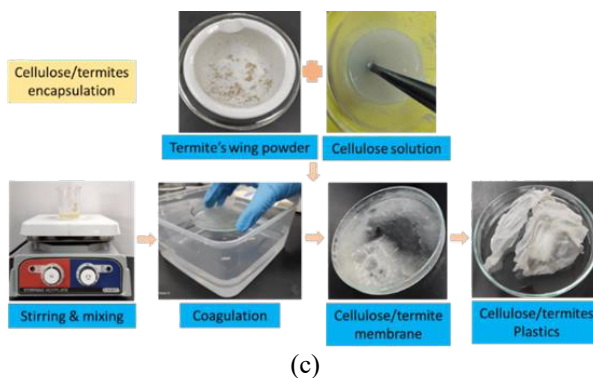
The powder of the wing's termites was embedded into the formed cellulose solution and stirred until homogeneous cellulose/termites' solution was formed. Consequently, the solution was cast on a glass plate and immediately put into coagulation bath containing 5% H<sub>2</sub>SO<sub>4</sub> solution. After a minute of solvent transfer between solution and the acid, a piece of transparent film was formed. Ultimately, the cellulose film was air dried to form a bioplastic film as shown in Figure 1(c).



(a)



(b)



**Figure 1.** Flow process of (a) grinding of wing's termites (b) bleaching and cellulose dissolution and (c) cellulose/termite's encapsulation.

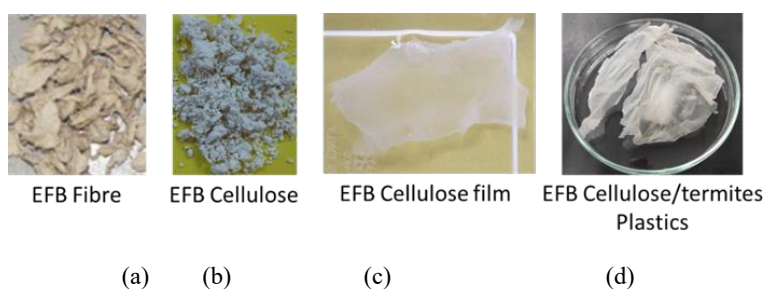
### Characterisation

Physical properties of the samples were observed based on the colour and structure of the samples. Meanwhile the chemical properties of the samples were analysed using Fourier-transform infrared spectroscopy (FTIR). The surface morphology observation of the membranes samples was studied using scanning electron microscope (SEM).

## RESULTS AND DISCUSSION

### Physical Properties of cellulose and cellulose/termite bioplastic

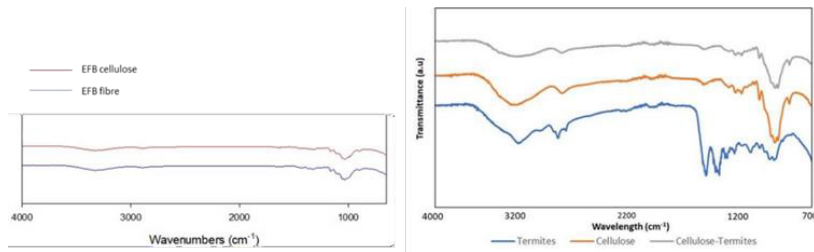
Figure 2 shows the physical structure of the samples. Figure 2(a) shows the colour for EFB has been changed from brownish to white (Figure 2(b)) which represent the loss of lignin in the EFB due to the bleaching process. Meanwhile, the sample of EFB cellulose was transformed from Cellulose I (EFB cellulose) into cellulose II (regenerated cellulose film) as can be seen in Figure 2(c). The regenerated cellulose film then was air-dried, and it becomes plastic (Figure 2(d)).



### Chemical Properties of cellulose and cellulose/termite bioplastic

Figure 3(a) shows the functional groups analyses of EFB and the transformation of functional groups after the bleaching process which is the EFB cellulose. The major peak can be observed at 3329 cm<sup>-1</sup> which represents OH stretching vibration of the samples. Meanwhile, Figure 3(b) shows the functional group of termites and cellulose were changed after the regeneration of

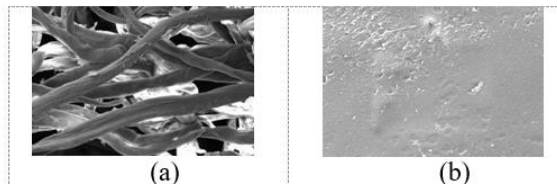
cellulose and mixing with termites has been carried out. This portrayed that the reaction has taken place



**Figure 3.** FTIR spectrum for (a) EFB fibre to EFB cellulose and (b) EFB cellulose, termites, and cellulose/termites.

### Surface morphology (SEM)

Figure 4 (a) shows SEM images on surface morphology of the EFB cellulose and cellulose bioplastics. After bleaching and alkaline processes, it shows the existence of individual fibre of cellulose. Hence, it shows that lignin which is located between the fibres has been removed during the bleaching process (Zaini et al. 2013). It is well known that the bleaching process is a process which is conducted to remove lignin from raw fiber (Tawakkal et al. 2010). Meanwhile, smooth surface of cellulose bioplastic has been observed as shown in Figure 4(b). The contact between the cellulose solution and the glass plate has contributed to the smooth and low porosity of the regenerated cellulose. In addition, the diffusion of acid during the coagulation process was slower on the surface which contacted the glass plate making it slow solvent exchange process (Kaco et al. 2014).



**Figure 4.** SEM images of (a) EFB-Cellulose and (b) EFB cellulose bioplastics

### CONCLUSION

Cellulose has been extracted from oil palm empty fruit using the bleaching process and winged termites were collected and underwent physical treatment. Both cellulose and winged termites was mixed to produce cellulose/termite bioplastic. FTIR result shows the cellulose functional groups were changed after the existence of termites. From SEM images, it shows that the fibrous cellulose was disturbed and become smooth after dissolution and regeneration process takes place. This cellulose/termite bioplastic has the potential to be used as bioplastic for food packaging and other applications.

## ACKNOWLEDGEMENTS

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